In-Space Autonomous ANTS Production Facility

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Systems concepts study results

- Revolutionary Aerospace Systems Concepts
  - GSFC, LaRC, GRC
- Prospecting Asteroids Mission
  - Advanced mission set in the 2020s
  - Identified mission requirements
  - Identified mission functions & capabilities
  - Examined current capabilities & trends
- Back propagated results to current capabilities
  - ART, NBF…

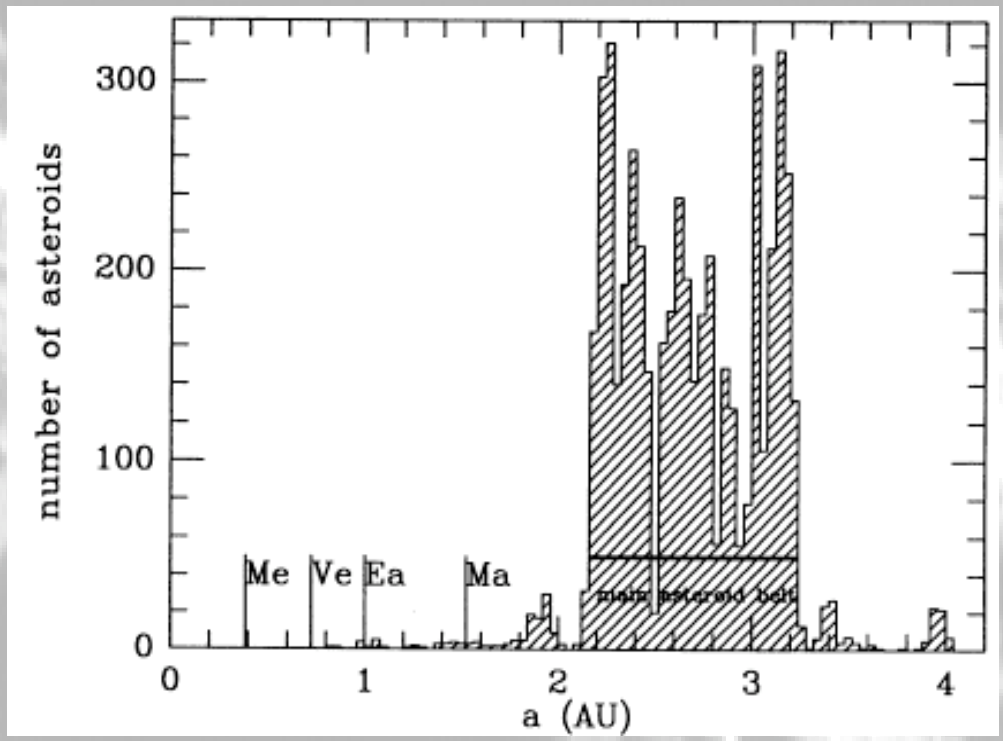
Main Belt Asteroids

Challenging Targets

- Thousands of 'targets of opportunity'
- Far from Earth & the Sun
- Most are small & dark: difficult targets
- Variable shape, gravitational field, and dynamic properties : difficult to "navigate"

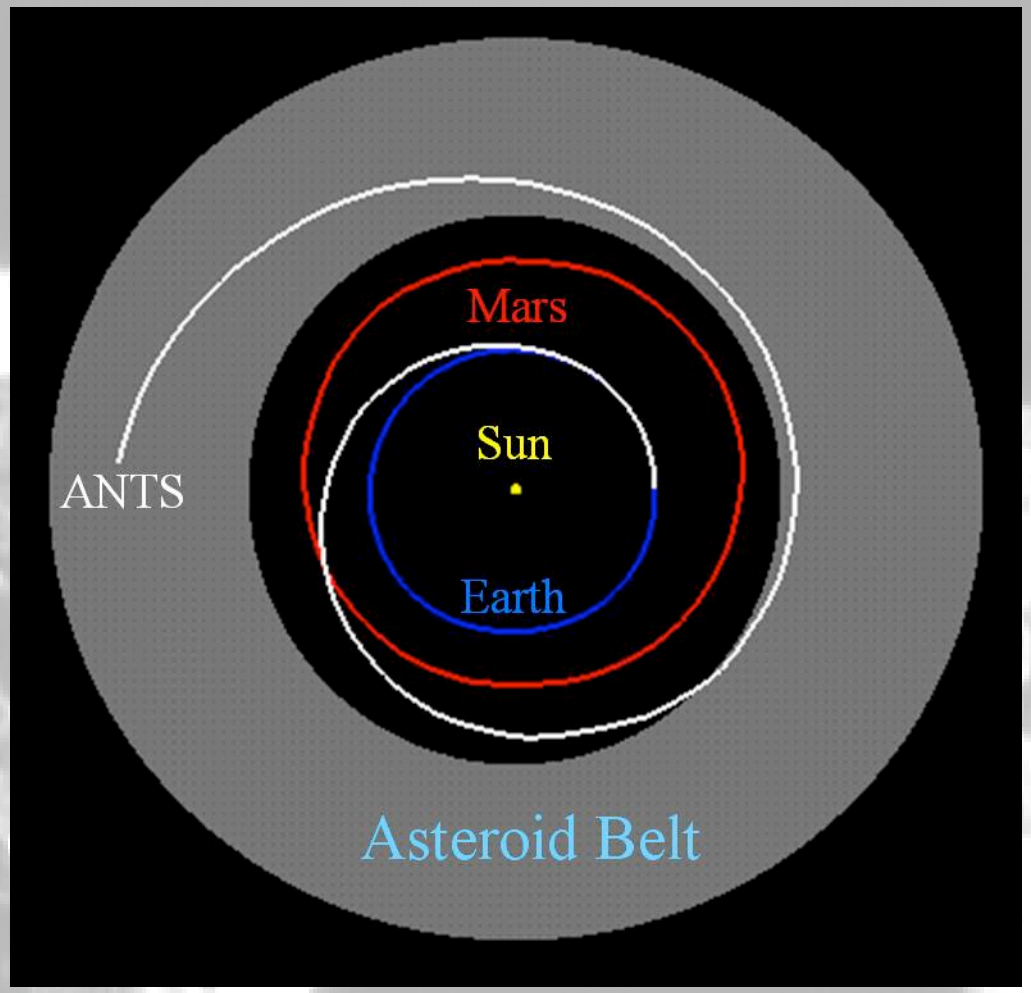
Main Belt Asteroids Characteristics

- Contains remnant planetesimals from Solar System formation
- ~ 10^5-10^6 objects (>1km diameter)
- Between the orbits of Mars & Jupiter (2.1 AU – 3.3 AU): between inner "rocky" & outer "gaseous" planets
- Surface of largest 1000 observed asteroids is ~ 70% the area of Mars.
- The remainder may dwarf the surface area of the Earth.
- Refractory (Fe, Ni, Si) materials dominate inner belt; Volatiles (NH_4, CH_4, H_20) abundant in outer belt
- Wide range of processes & history represented
- Both "processed" & "primordial" materials present: Most "primitive" material in Solar System



PAM Navigation: Sailing to the remote targets

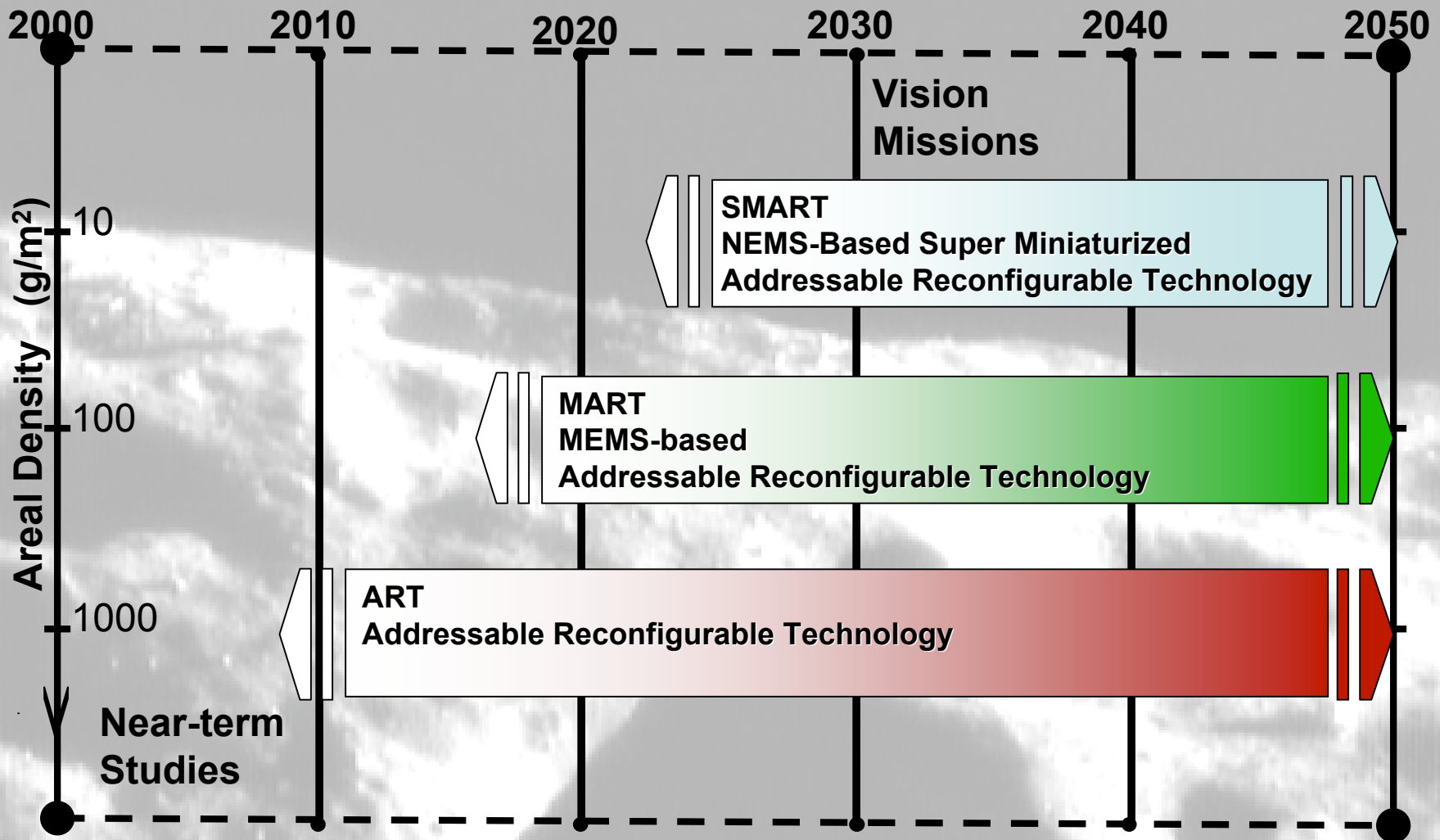
Solar sail trajectory to the Asteroid Belt



The ANTS Architecture

- Missions are applications of the Architecture, e.g., RASC studies of the Prospecting Asteroid Mission (PAM) and the Saturn Autonomous Ring Array (SARA)
- Insect hierarchical organization
  - Many types of specialized workers – 'science craft'
  - Many workers of each type
  - Intelligent swarm interactions
- Fully autonomous – 'Launch it and forget it'
  - Complex-adaptable-evolvable
  - Integration of body and neural system
- Miniaturization via nanotechnology to pico (≤ 1 Kg) class
- Self-repair capabilities – radically reconfigurable gossamer space frame
- Architectural approach enables technology back propagation
  - Addressable architecture – LCD Screen analogy
  - Near-term manufacturability

ANTS Development Long-Term Enabling Technology Timeline



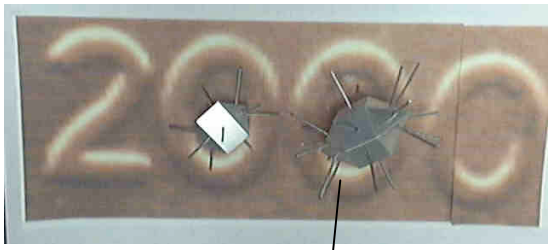
ANTS/PAM Needs

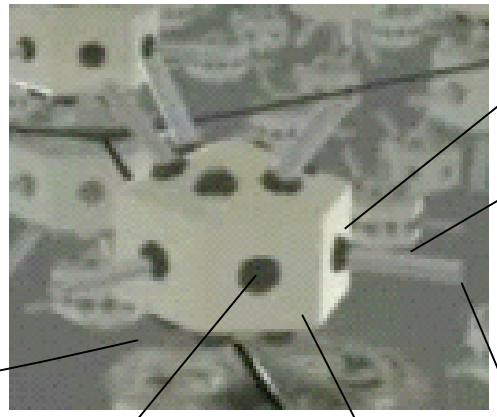
- Large numbers of spacecraft
- Low mass, low areal density
- Active shape control
- Standardized, robust parts
- Highly parallel system

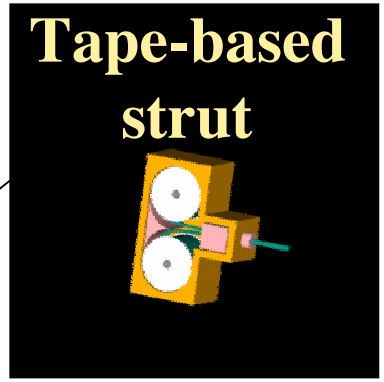
ANTS/PAM
Spacecraft Construction

- Ground based
  - Fabrication, packaging
- Transport to Autonomous Research Facility
- ARF provides infrastructure (e.g. templates)
- Nodes self assemble into Gossamer structures
  - In parallel under local control
- Structures stow themselves
  - Moved around by robotic assembly infrastructure
  - Moved around by helper spacecraft

Assembly in Space
Nodes & Struts







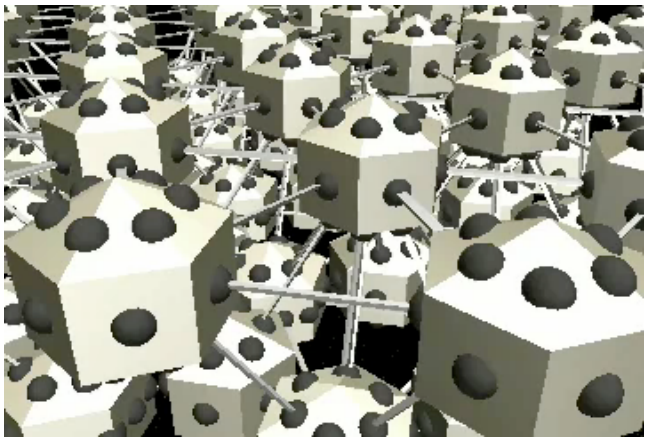
Extensible/retractable strut

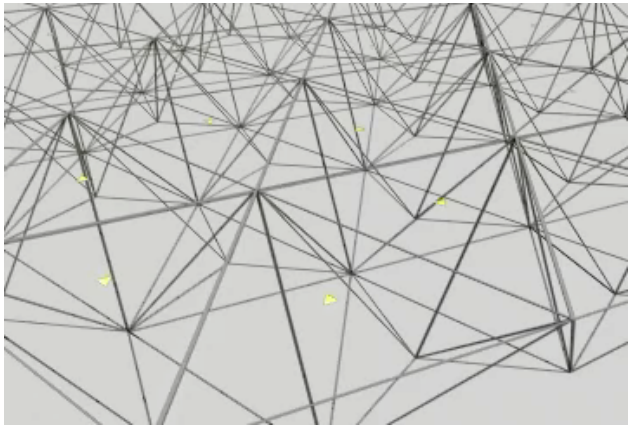
Clamping mechanism on end

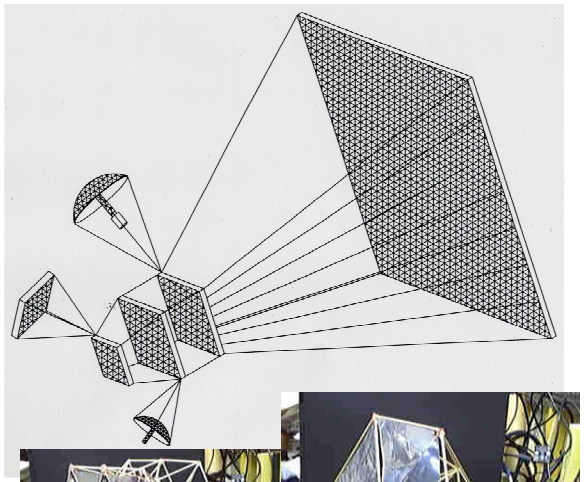
Socket for clamp

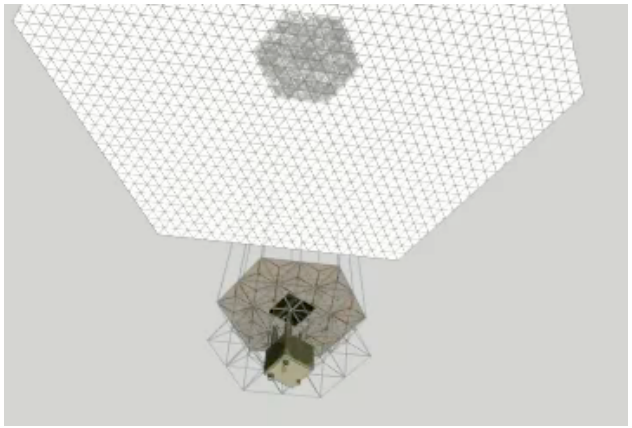
Node

Assembly in Space
Structures



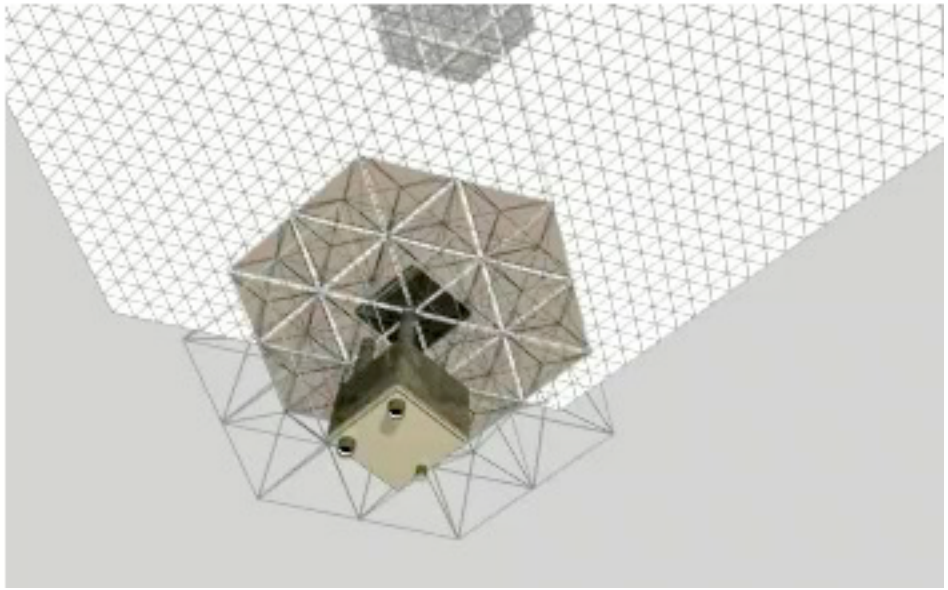


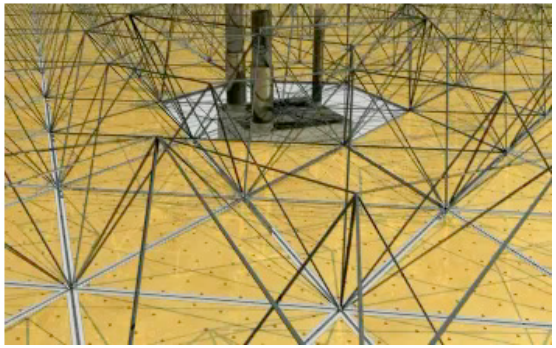


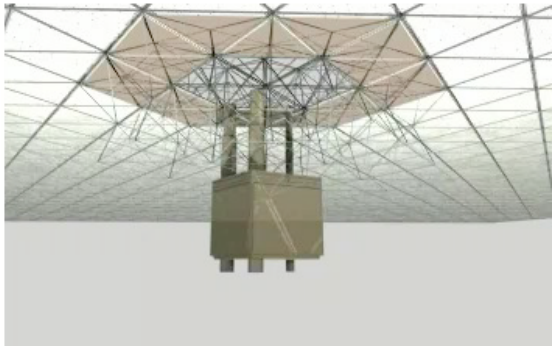


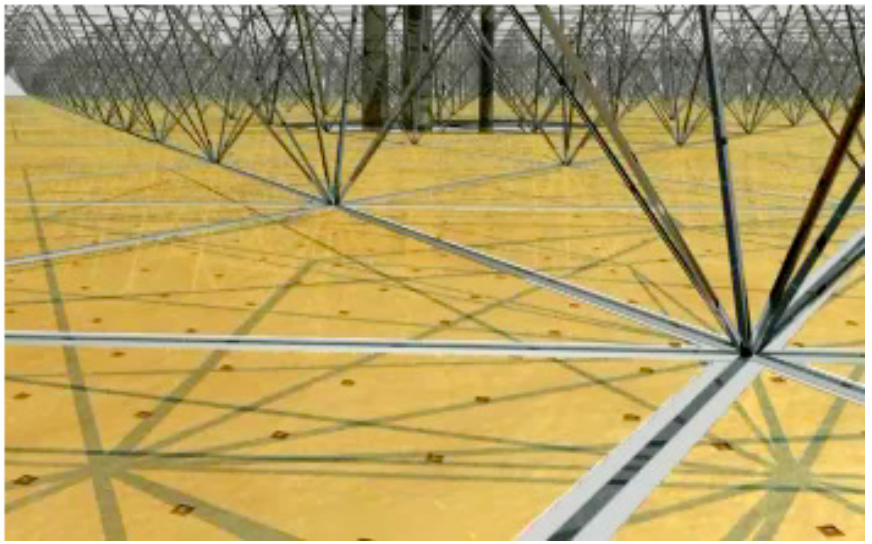
Assembly in Space

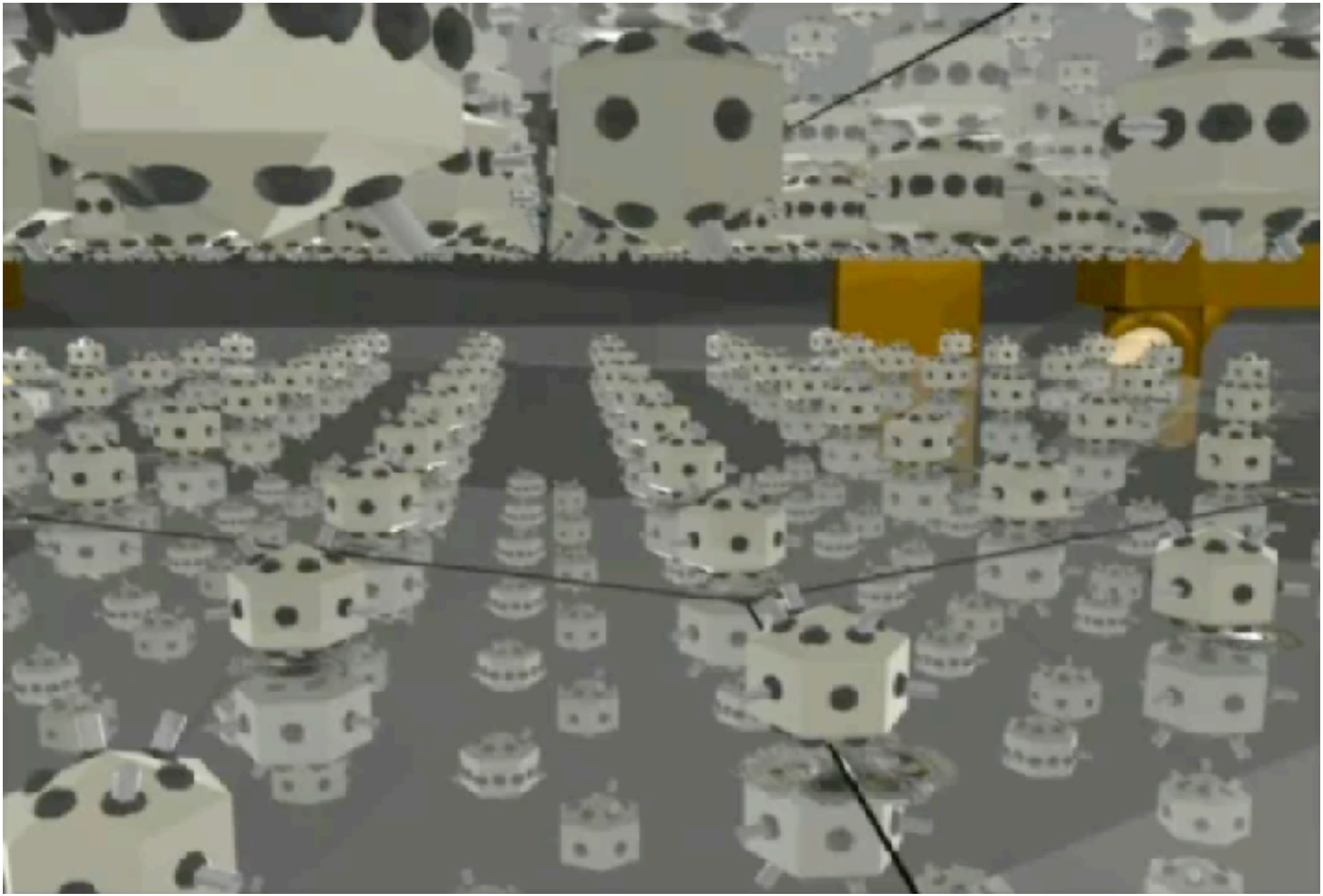
The Spacecraft

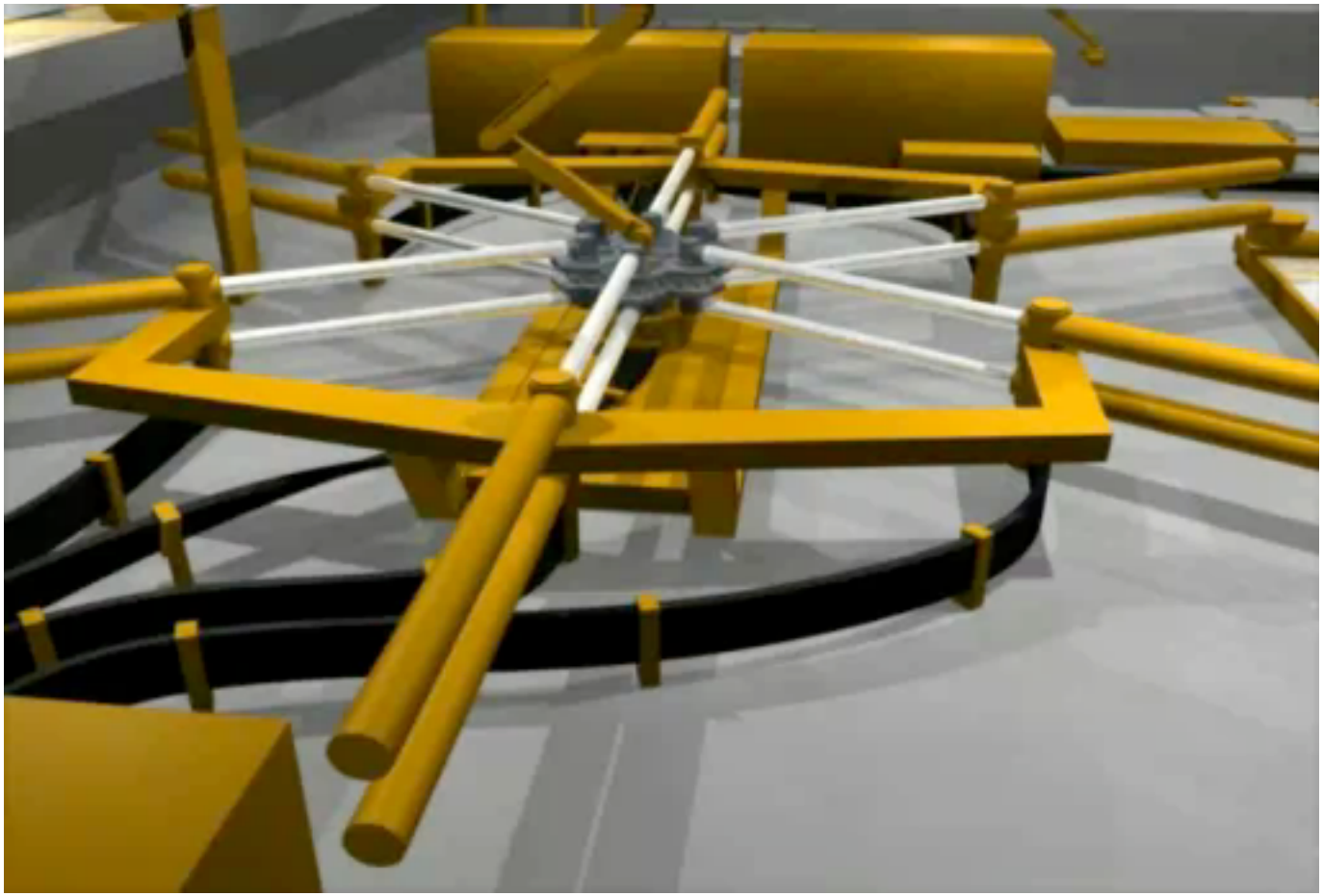




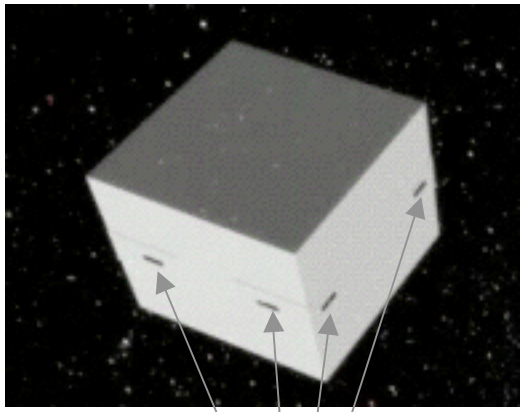




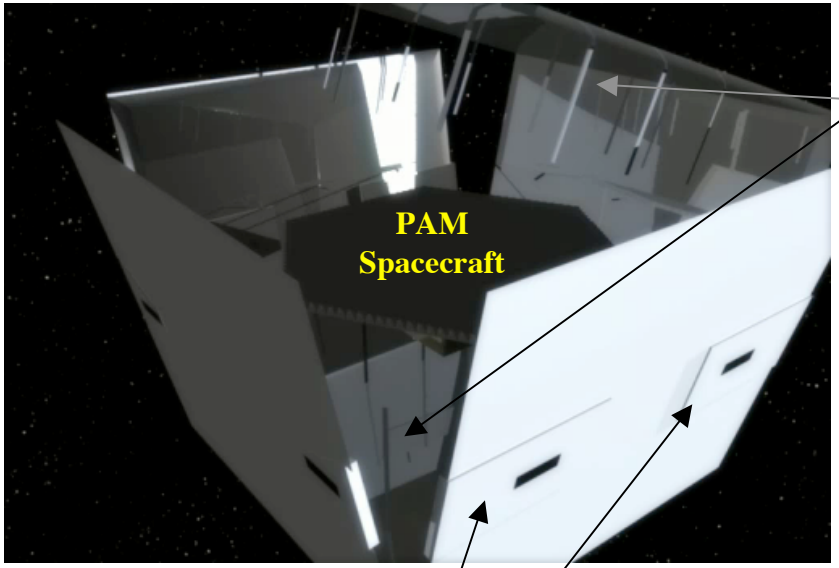




Assembly in Space
Carrier Shell



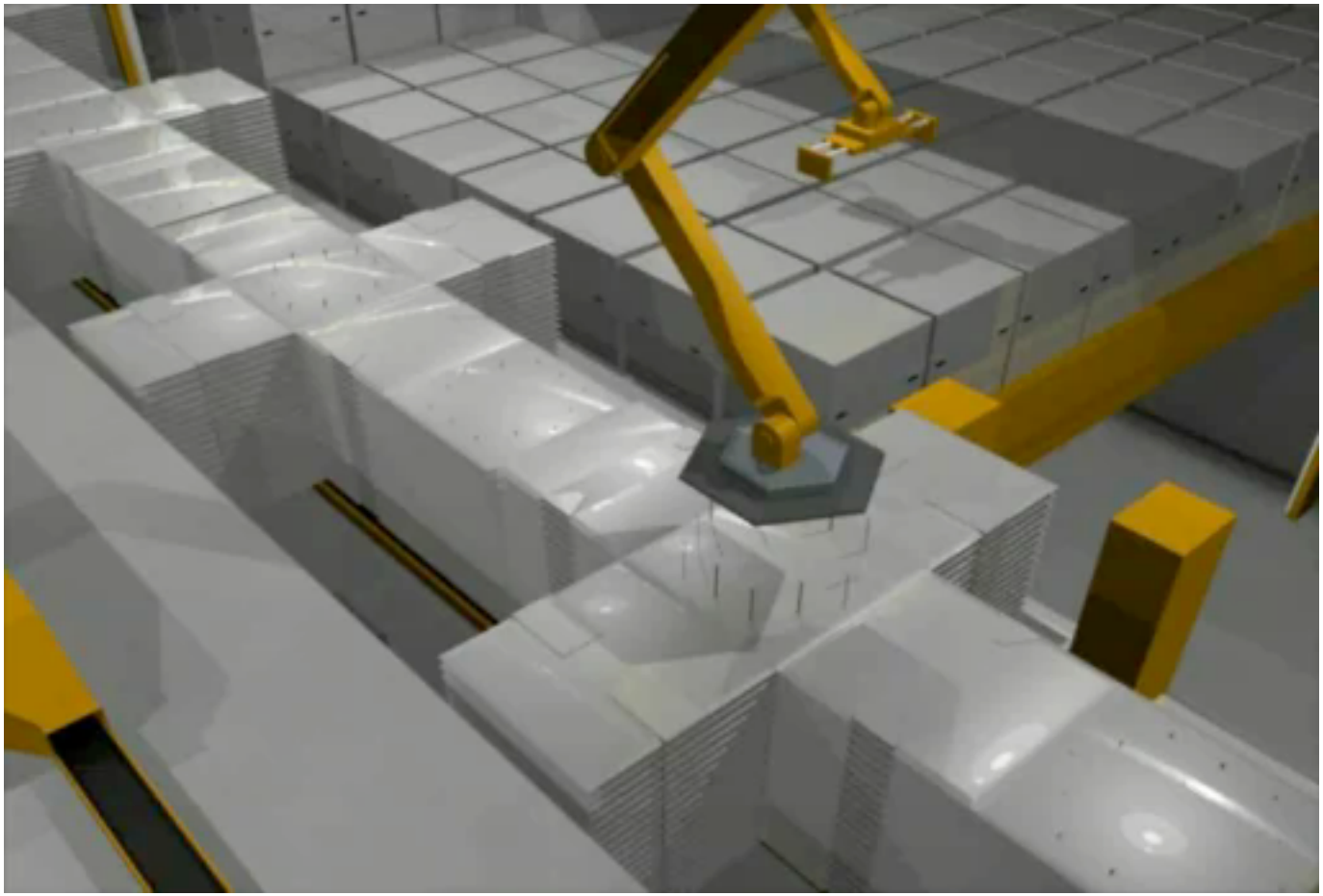
Thrusters



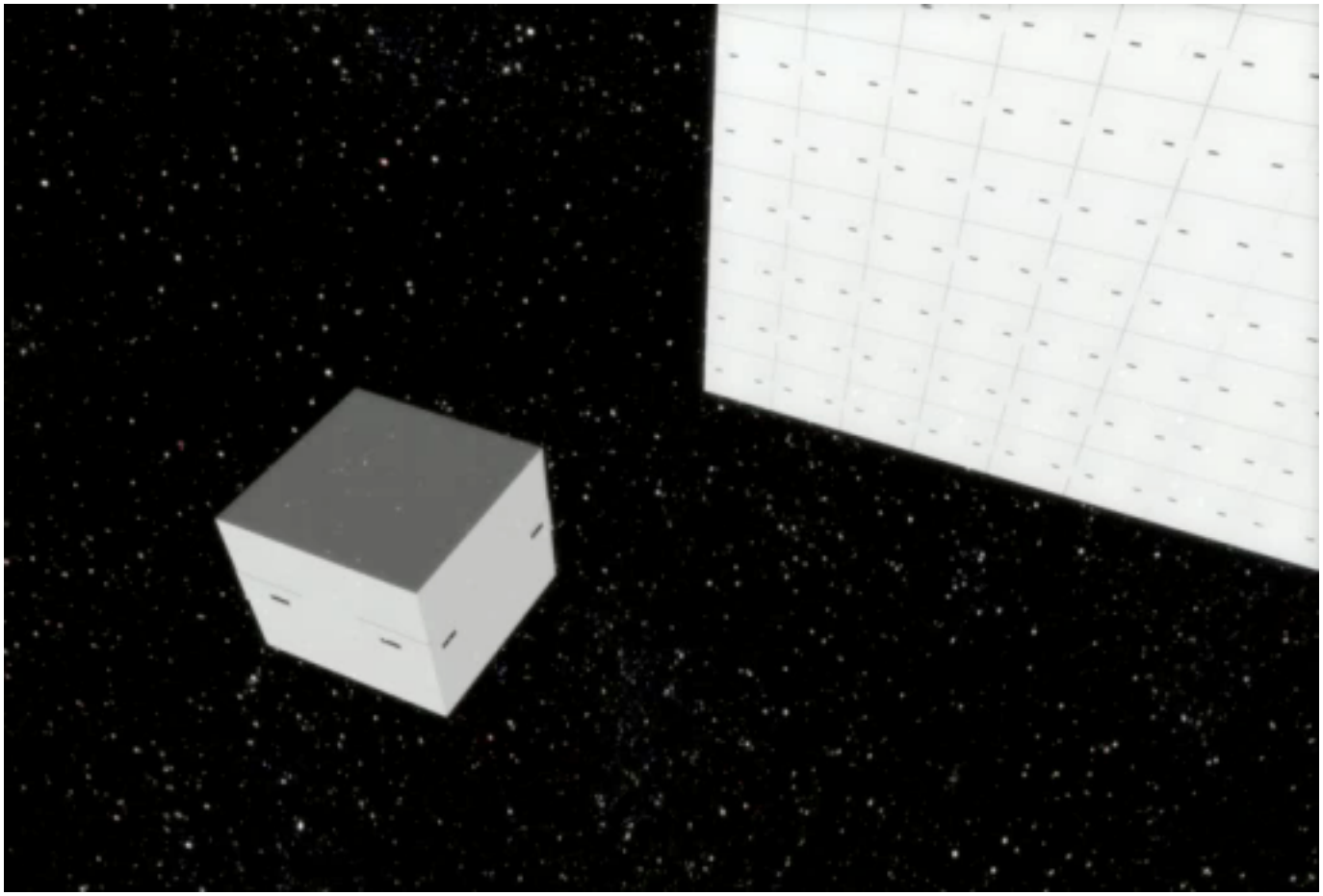
Tethers

Patch Antennas

Assembly in Space
Carrier Shell Integration



Assembly in Space
Deployment from Carrier Shell



Conclusion

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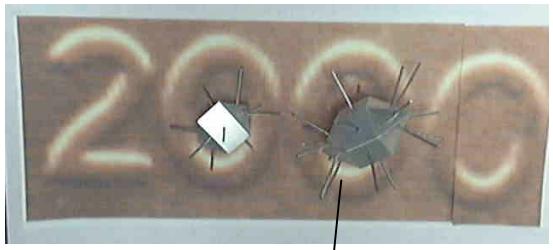
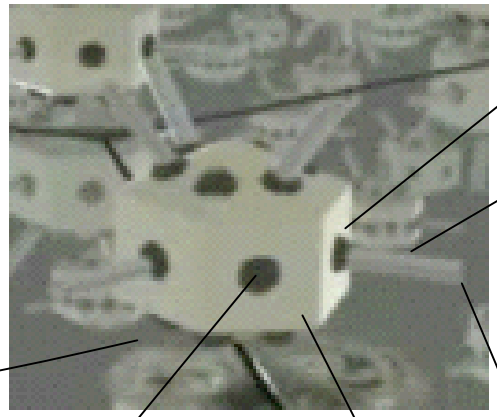
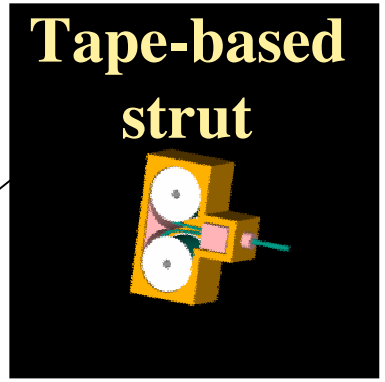
- *In space assembly*
  - *Improves deployment options*
    - *Energetically favorable trajectories (ANTS/PAM)*
    - *Assembly en route or in place*
  - *Separates concerns*
    - *Launch environment hardening*
    - *Spacecraft engineering*
  - *Based on advanced nodal elements*
    - *Can be built within ANTS framework*
    - *Requires some intelligence*
      - *ART, addressable in near-term*
      - *SMART, autonomous in the far-term*
    - *RF signaling*
  - *Creates options for dealing with faults & failures*

SMART Structures

Nodes & Struts







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